ILLINOIS
COAL MINING INVESTIGATIONS
COOPERATIVE AGREEMENT

State Geological Survey
Department of Mining Engineering, University of Illinois
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BULLETIN 4

Coal Mining Practice

IN

District VII

BY

S. O. ANDROS

Field Work by S. O. Andros, C. M. Young and J. J. Rutledge

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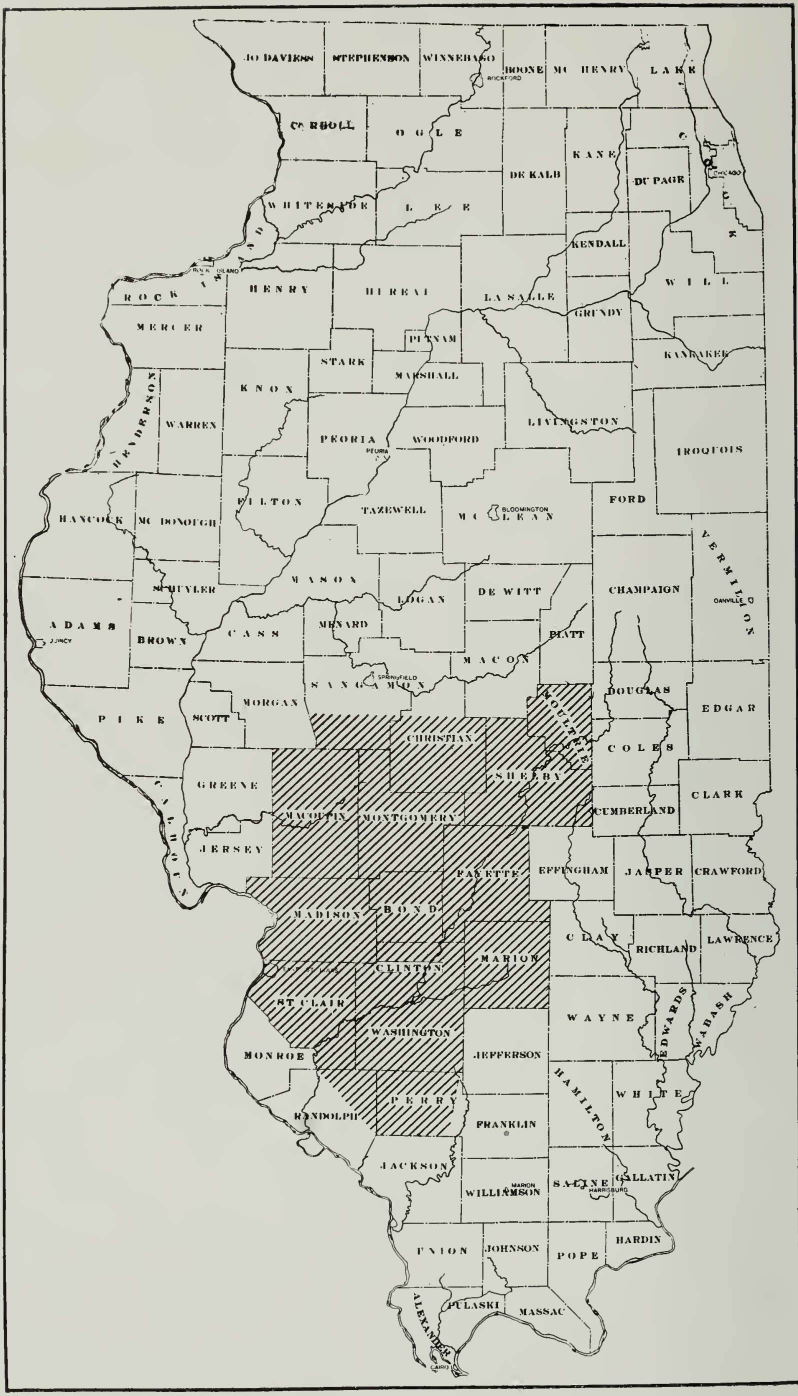

Fig. 1. Map showing the area (shaded) of District VII.

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COAL MINING PRACTICE IN DISTRICT VII

By S. O. ANDROS

Field Work by S. O. Andros, C. M. Young and J. J. Rutledge

INTRODUCTION

District No. VII of the Illinois Coal Mining Investigations, as shown in fig. 1, includes all mines operating in coal bed 6 west of the Duquoin anticline and north as far as an east-west line about 6 miles south of Springfield. It comprises the following counties: Bond, Clinton, Fayette, Macoupin, Madison, Marion, Montgomery, Moultrie, Randolph, St. Clair, Shelby and Washington, together with that portion of Perry County west of the Duquoin anticline and those portions of Christian and Sangamon Counties in which bed 6 is mined. Fayette county at present does not contribute to the production of the district. Table 1 gives general data for district VII by counties.

A detailed description of the districts into which the State has been divided and the method of collecting the data upon which this bulletin is based is contained in Bulletin 1, A Preliminary Report on Organization and Method.

The coal output of the district for the year ended June 30, 1912, was 22,454,672 short tons, 39.1 per cent of the total production of the State. This output came from 196 mines, 150 shipping and 46 local, employing 27,847 men and operating on an average of 158 days in the year. The number of employees was 35.1 per cent of all employed in coal mining in the State. The use of undercutting machines made possible the production of 39.1 per cent of the State's coal output by 35.1 per cent of the employees. In the fiscal year 1912, machines undercut 13,558,530 tons, 60.3 per cent of the production of the district. The large percentage of undercut coal produced in the district reduces powder consumption. During the year ended June 30, 1912, 426,353 kegs of powder or 32.4 per cent of the total powder consumption of the State were used in the mines of the district. Table 2 gives comparative statistics for District VII and for the State for the year ended June 30, 1912.

The operators of this district rendered every possible assistance in the study of their mines and freely gave all information requested. Grateful acknowledgments are due to them and to the superintendents and mine managers who accompanied the engineers through the workings. The generous help of the mine officials has made possible the collection of accurate data covering each phase of mine operation. Especially valuable aid was given by Mr. John H. Ross, Superintendent of the Superior Coal Company; Mr. G. E. Lyman, Chief Engineer, Madison Coal Corporation; Mr. T. G. Hebenstreit, Superintendent, New Staunton Coal Company; Mr. D. F. Cameron, General Superintendent, St. Louis and O'Fallon Coal Company; Mr. W. L. Morgan and Mr. Walton Rutledge, State Mine Inspectors; and Mr. T. C. Wright, County Mine Inspector, St. Clair County.

TABLE 1.—*General data by counties for District VII*[1] *for year ended June 30, 1912.*

County	No. mines		Production in short tons	Tons mined by machine	Average days of operation	Total number employees	No. surface employees	No. kegs powder used	Haulage				Accidents to employees	
									No. mines using—					
	Shipping	Local							Locomotives	Cable	Mules	Hand-power	No. killed	No. injured
Bond	2	0	183,180	0	160	316	26	9,063	0	0	2	0	1	1
Christian[2]	7	1	1,270,926	175,516	130	1,913	154	29,771	8	0	0	0	1	24
Clinton	5	0	1,012,982	405,970	165	1,315	126	25,758	5	0	0	0	3	13
Macoupin	13	4	4,913,050	4,310,281	181	4,681	356	58,715	11	0	3	3	11	49
Madison	16	11	3,454,536	2,776,185	167	4,385	401	46,842	12	0	15	0	16	85
Marion	6	0	1,203,947	516,090	205	1,399	127	30,792	4	0	2	0	0	9
Montgomery	10	0	2,280,341	1,311,686	177	2,672	226	32,825	4	2	4	0	12	35
Moultrie	1	0	54,162	0	229	68	12	415	0	0	1	0	0	0
Perry[3]	11	2	708,167	473,901	136	1,234	111	13,985	4	0	7	2	2	3
Randolph	10	4	762,816	445,823	145	1,149	87	19,118	4	0	7	3	1	5
St. Clair	58	17	4,516,588	2,227,862	132	5,856	487	100,943	20	1	54	0	13	53
Sangamon[2]	6	0	1,775,550	840,790	183	2,165	173	49,527	4	0	2	0	2	8
Shelby	2	6	128,544	53,426	193	275	36	1,525	1	0	1	6	0	0
Washington	3	1	189,883	21,000	161	419	32	7,074	1	0	3	0	0	0
Total	150	46	22,454,672	13,558,530	158[4]	27,847	2,354	426,353	78	3	101	14	62	285

[1]Compiled from the Thirty-first Annual Coal Report of Illinois.
[2]Working No. 6 bed.
[3]West of Duquoin anticline.
[4]Averaged by mines; not by counties.

TABLE 2.—*Comparative statistics for District VII and the State for the year ended June 30, 1912.*

	District (All mines)	State (All mines)	Percent of District
Total production	22,454,672	57,514,240	39.1
Average daily tonnage	142,118	359,464	......
Number tons mined by machines	13,558,530	25,550,019	53.2
Kegs of powder used in blasting coal	426,353	1,313,448	32.4
Average days of active operation	158	160	......
Number days' work performed in 1912	4,399,826	12,705,760	34.6
Total employees	27,847	79,411	35.1
Number surface employees	2,354	7,049	33.4
Number underground employees	25,493	72,362	35.3
Number face-workers (miners, loaders, and machine men)[1]	19,345	53,318	36.3
Number underground employees per each surface employee	10.8	10.3	......
Number tons mined per day per employee	5.1	4.5	......
Number tons mined per day per surface employee	60.5	50.9	......
Number tons mined per day per underground employee	5.6	4.9	......
Number tons mined per day per face-worker[1]	7.3	6.7	......
Number fatal accidents	62	180	34.4
Percent from falling rock or coal	54.8	54.4	......
Percent from pit cars	24.2	18.8	......
Percent from explosives	6.5	7.2	......
Percent from gas explosions	3.2	6.9	......
Number deaths per 1000 employees	2.3	2.3	......
Number tons mined to each life lost	362,172	319,524	......
Number non-fatal accidents	285	800	35.6
Percent from falling rock or coal	34.7	45.5	......
Percent from pit cars	29.5	26.3	......
Percent from use of explosives	3.1	2.6	......
Percent from gas explosions	1.4	2.8	......
Number injuries per 1000 employees	10.2	10.1	......
Number tons mined to each man injured	78,788	71,893	......

[1]Shipping mines only.

DESCRIPTION OF COAL BED

Bed No. 6 of the Illinois State Geological Survey correlation in this district differs greatly in physical appearance, thickness and chemical composition from the same bed on the east side of the Duquoin anticline. Table 3 gives average of analyses[1] of 58 samples taken in 16 mines in the district east of the Duquoin anticline, and of 76 samples taken in 25 mines in District VII.

TABLE 3.—*Chemical and physical characteristics of coal in bed 6, Districts VI and VII.*

District	Average thickness of coal in feet	No. samples	Proximate analysis of coal 1st; "As recd." with total moisture. 2nd; "Dry" or moisture free				Sulphur	B. t. u.	Unit coal B. t. u.
			Moisture	Volatile matter	Fixed carbon	Ash			
VI (East of Duquoin anticline)	9	58	9.21	34.00	48.08	8.71	1.53	11825	....
			Dry	37.45	52.96	9.59	1.68	13025	14585
VII	7	76	12.56	38.05	39.06	10.33	4.01	9848	....
			Dry	43.52	44.67	11.81	4.59	12406	14377

In District VII the No. 6 coal does not have the bright luster of the No. 6 coal to the east of the Duquoin anticline. The thickness varies from 2½ to 14 feet, averaging 7 feet. The bed is characterized by its numerous dirt and sulphur bands of which the most persistent throughout the district is the "blue band" of hard dark gray or black shale from ½ inch to 4 inches thick situated in places 6 inches above the floor, but at an average height of 18 inches. Bands of pyrites from ½ inch to 4 inches thick are located at varying heights in the bed; in places are other bands of impurities called by the miner "steel band", "nine-inch band", or "dirt band" according to their hardness and location. There is a well-defined parting plane in the coal about 18 inches from the roof. The upper bench or "top coal" is left where the roof is black shale and where the coal is 7 feet thick or over. The roof is either a non-

[1]Analyses made by J. M. Lindgren under the direction of Prof. S. W. Parr, Department of Applied Chemistry, University of Illinois.

calcareous black shale, a calcareous gray shale called locally white-top or soapstone, an unconsolidated dark-gray or black shale called clod made up of fragments of varying size and hardness extremely difficult to support, or a hard gray limestone called "rock top". A poorly defined cleat or cleavage in the coal may be seen in some places. Table 4 gives for each mine inspected in District VII the kinds of roof found in the workings and the average thickness of coal.

The floor throughout the district is a fireclay which generally heaves when wet.

TABLE 4.—*Roof material and average thickness of bed.*

No.	Material of roof	Average thickness of coal in feet
66	Shale, limestone	8
67	Clod, shale, limestone	8
68	Shale	7
69	Clod, shale, limestone	8
70	Clod, shale, limestone	7
71	Shale, limestone	8½
72	Shale, limestone	6
73	Shale, limestone	6
74	Shale, limestone	7¾
75	Clod, shale, limestone	8
76	Shale, limestone	7
77	Shale, limestone	8
78	Clod, shale, limestone	6½
79	Clod, shale, limestone	6½
80	Shale, limestone	6
81	Clod, shale, limestone	7½
82	Clod, shale, limestone	6½
83	Clod, shale, limestone	6
84	Clod, shale, limestone	8
85	Limestone	8
86	Shale, limestone	6
87	Shale, limestone	6½
88	Clod, shale, limestone	5¾
89	Shale	7
90	Shale	6½

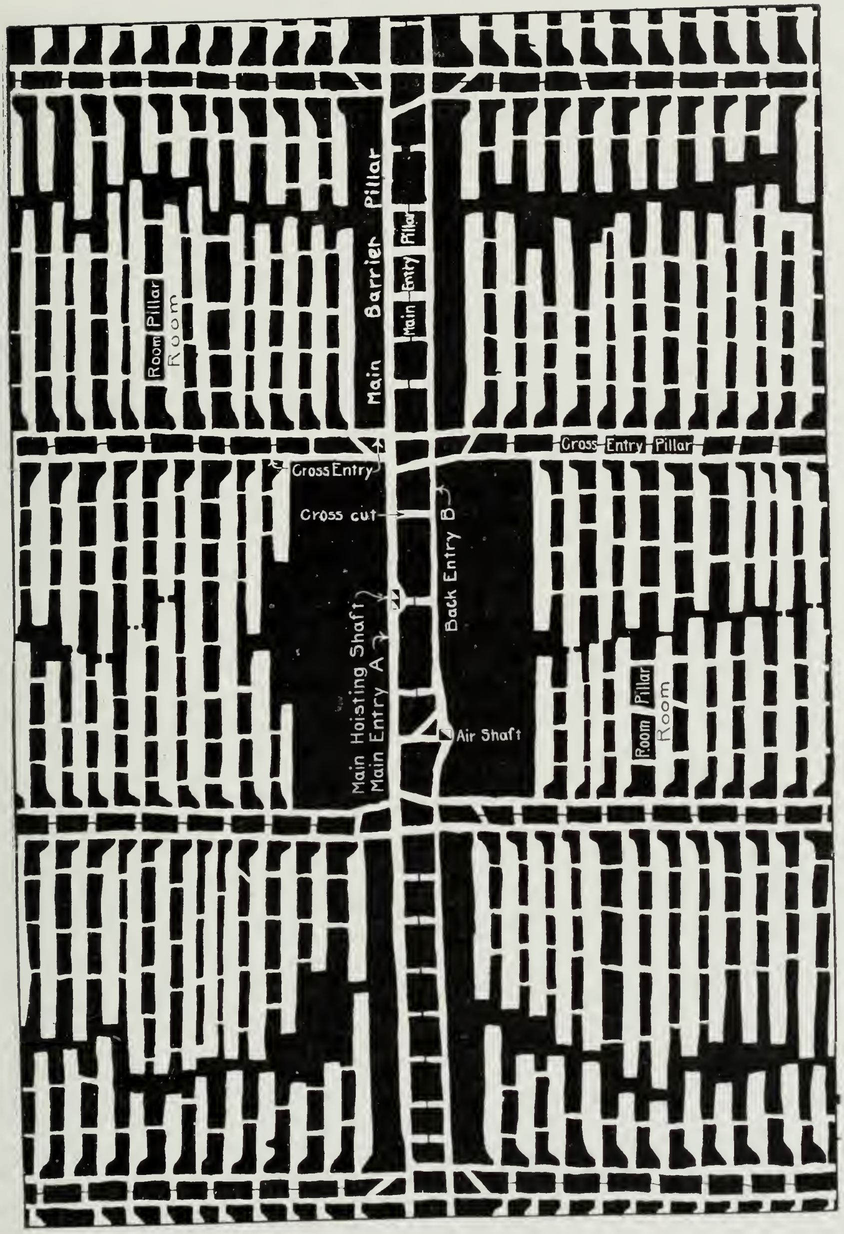

FIG. 2. Plan of room-and-pillar mine.

MINING PRACTICE

As bed No. 6 of this district lies at considerable depth the coal is generally reached by shafts. The number of drift and slope mines totals six. The coal lies at greatest depth near Centralia where it has 707 feet of overlying strata.

SYSTEMS OF MINING

The usual projection in the district is according to the unmodified double entry room-and-pillar system as shown in fig. 2, but there are many mines worked on the panel system. (See fig. 3). An occasional instance of main triple entries is found. The district has several mines with highly developed mining methods adapted to Illinois beds.

As naturally would be expected, the more highly developed practice is found at mines recently established. The occasional instance of panel working in old mines is where the mining system has recently been changed from room-and-pillar.

In general, entries and rooms are driven wider under rock top than under shale roof. Varied roof conditions often make necessary different entry and room widths in different sections of a mine. In many mines the entries and rooms under rock top are too wide and the pillars too narrow—a condition that has brought about squeezes which sometimes even jeopardized the shaft. Main entries 35 feet wide in which no timbering was done were found. In one mine room pillars were so gouged under rock top that on 65-foot room centers the dimensions were: room width, 55 feet; room pillar width, 10 feet. In two mines squeezes causing surface subsidence occurred in sections where rooms were 30 feet wide and room pillars 5 feet wide. In 13 of the 25 mines examined in this district squeezes have occurred; they generally began in a section of which the roof was limestone. In mines where the rooms are not frequently surveyed there is no definite knowledge of room pillar width except at crosscuts. A blow-through from a room into the one adjacent is not uncommon.

In some parts of the district joints in the roof prevent easy working and in fact will cause it to fall badly when rooms or any wide workings are driven north or south. The cleat in the coal usually is not strongly enough marked to make a perceptible difference between driving on the butt or

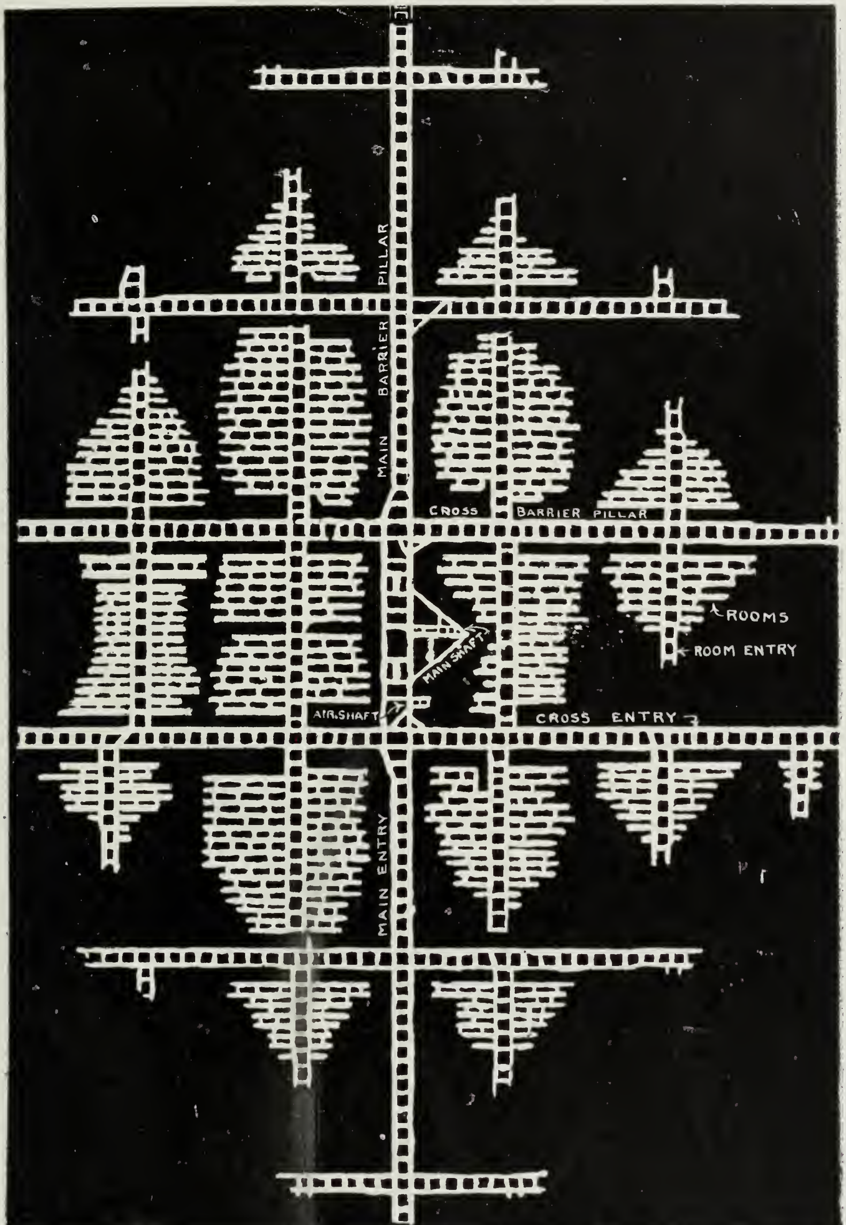

Fig. 3. Plan of panel mine.

on the face; but in several mines to avoid excessive roof falls rooms are turned only to the east or west.

An unusual condition in one mine causes lack of stability of entry-and-room-pillars when gouged. Under the coal the fire-clay, which is rather soft and 6 feet thick in places, has in it large round boulders harder than the general mass of clay. Where

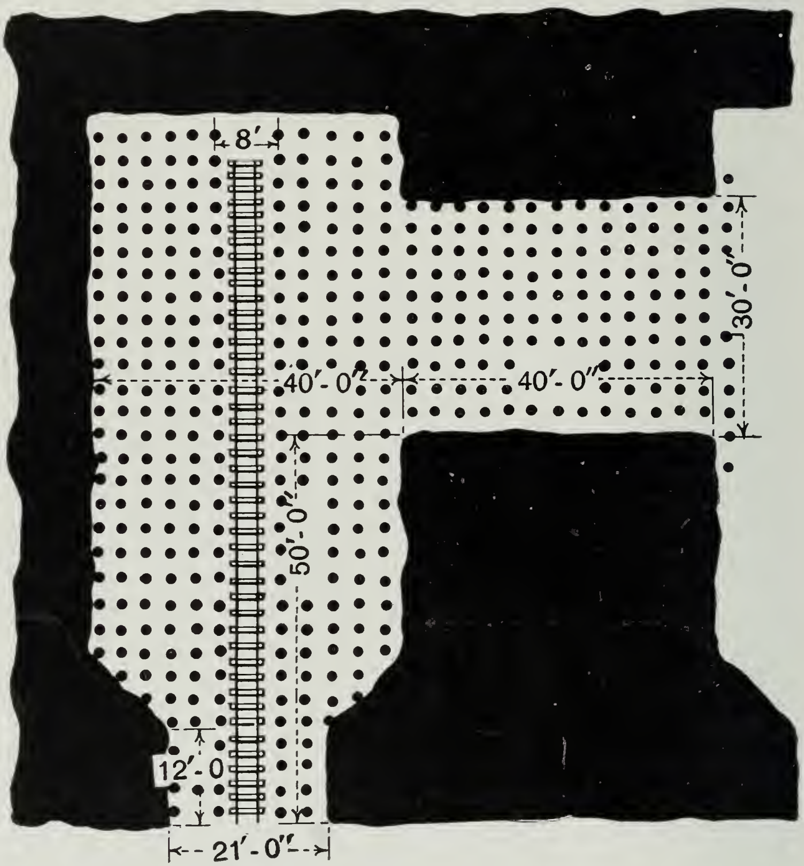

FIG. 4. Widening room-neck on both sides.

these boulders are located under pillars they present uneven bearing surfaces and the pillars break as the roof weight comes on them.

Table 5 gives dimensions of workings at each mine examined.

This table shows that a very low percentage of the coal in the bed is brought to the surface. The average per cent of recovery for the district is 55; that is 45 per cent of the coal in the bed is left in the mine and probably will not be recovered in the future. The figures for percentage of coal gained were obtained from the books of the operating companies. Because of the large area of this district, the failure to bring to the surface a proper percentage of the coal in the bed is a matter for serious consideration. A contributing cause of this waste of natural resources is the fear of bringing about surface subsidence and attendant damage suits. It would probably be economy for the operating companies to purchase the surface overlying the coal to be removed. Pillars could then be robbed and 30 per cent more of the coal bed could be recovered.

In turning rooms off the entries the width of room neck, its length to the point where widening begins, and the distance required to reach full room width vary with each mine and often in different sections of the same mine. It is impracticable to maintain the same width of room neck under a black shale roof as that left under limestone top which requires no support for spans less than 30 feet. The width of crosscuts in entry pillars and in room pillars also varies for each mine. In 24 of these 25 mines widening to full room width was done both to the right and left at an angle of 45 degrees after the room neck was driven as shown in fig. 4. In one mine the right side of the neck was continued as the right rib of the room, and widening was done to the left at an angle of 45 degrees. See fig. 5.

Before July 1, 1913, on which date a new provision of the State law required the first crosscut between rooms on any entry to be not more than 60 feet distant from the rib of the entry, the first crosscut through the pillar on one side of a room was often driven at a distance of but 50 feet from the entry, and the first through the opposite pillar at a distance of 80 feet. It was generally supposed that after the working had extended beyond the crosscut this method furnished more air to the face than that of having crosscuts directly opposite each other. Besides, the staggered crosscuts left a shorter unsupported roof.

To avoid paying yardage in driving crosscuts between main and back entries and between cross entries, in one mine crosscuts are not driven full width completely through the pillar. Narrow work is avoided and danger of squeeze reduced, as shown in fig. 6, by offsetting the crosscut. In another mine

TABLE 5.—*Dimensions of workings in feet.*

No.	Depth of shaft	System of mining	Age of mine in years	Entry width			Entry pillar width		Barrier pillar width		Room		Room pillar width	No. rooms on room entry	Room necks		Entry to full room width	Width of crosscuts	Entry to first crosscut	Squeezed?	Percent of bed gained
				Main	Cross	Room	Main	Cross	Main	Cross	Width	Length			Width	Length					
66	332	Panel	6	21	21	21	40	40	110	75	30	300	40	....	21	25	50	21	50	Yes	56
67	320	Panel	22	12	12	12	30	30	60	60	30	300	10	30	9	6	32	9	50	No	63
68	387	Room-and-pillar	7	21	16	....	40	40	....	27	32	235	33	38	9	15	27	20	50	Yes	50
69	290	Panel	27	12	12	12	30	30	60	60	23	200	22	27	12	9	30	12	60	No	47
70	92	Room-and-pillar	24	14	14	....	50	50	50	50	30	300	30	....	21	25	50	21	60	No	50
71	194	Panel	11	10	10	10	40	40	75	60	38	200	27	....	9	18	36	10	60	Yes	51
72	287	Room-and-pillar	8	21	21	....	40	40	....	....	30	300	30	....	21	6	....	21	60	No	56
73	318	Panel	9	21	21	21	60	40	60	60	30	300	20	13	21	12	30	21	60	No	60
74	330	Panel	13	12	12	12	60	60	50	50	30	265	30	14	12	12	30	12	50	Yes	50
75	310	Panel	8	12	12	12	50	40	50	50	30	250	18	25	12	18	30	12	50	Yes	52
76	370	Panel	8	10	10	10	50	40	75	75	28	225	27	....	10	20	35	10	60	Yes	44
77	462	Panel	4	14	14	14	50	50	100	100	30	250	25	40	22	22	28	21	65	Yes	63
78	160	Room-and-pillar	10	21	21	....	55	45	55	....	32	250	41	....	21	24	34	21	50	Yes	56
79	127	Room-and-pillar	9	21	21	....	60	30	60	....	30	300	30	....	21	12	24	21	60	No	62
80	145	Room-and-pillar	40	12	14	....	18	35	60	....	30	250	30	....	21	18	38	21	70	No	59
81	200	Room-and-pillar	22	21	21	....	80	40	60	....	35	250	45	....	21	25	40	21	60	Yes	55
82	192	Room-and-pillar	9	14	21	....	42	42	60	....	40	250	40	....	21	18	36	30	50	No	63
83	140	Panel[1]	10	21	21	21	35	35	35	35	27	600	43	12	21	12	24	21	60	Yes	50
84	320	Room-and-pillar	12	21	21	....	39	39	40	....	30	240	30	....	21	15	25	21	60	No	60
85	440	Panel	7	12	12	12	50	50	50	50	35	250	19	25	9	9	25	12	70	Yes	55
86	536	Panel	3	12	8	12	100	50	100	50	25	400	25	16	12	18	30	8	50	No	52
87	707	Room-and-pillar	25	12	12	....	40	40	150	....	30	300	30	....	12	20	50	20	60	No	58
88	85	Room-and-pillar	15	12	12	....	20	20	40	....	29	250	17	....	12	6	16	12	60	Yes	65
89	85	Room-and-pillar	25	8	8	....	20	15	40	....	25	200	20	....	8	10	24	8	50	Yes	48
90	160	Room-and-pillar	4	21	9	....	60	30	30	....	33	250	17	....	9	12	24	12	50	No	63

[1]Small section operated on room-and-pillar system.

narrow work is avoided and a small stopping provided for as shown in fig. 7. The crosscut is driven its full width of 21 feet from one entry, while from the other of the pair it is driven only 6 feet wide for a distance of 12 feet. A large area of unsupported roof is left where this method is followed. An

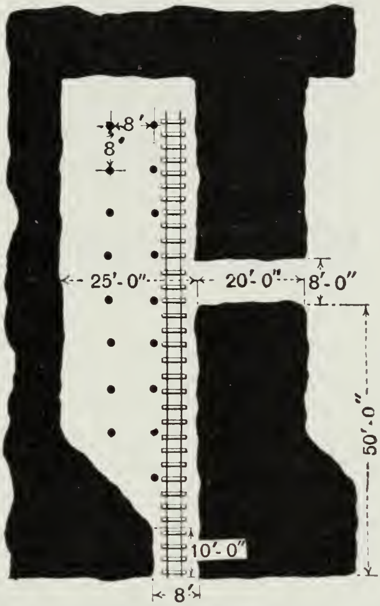

FIG. 5. Widening room-neck on one side only.

occasional instance of sheering the rib is found in the district, although the occurrence is not general. Shearing in a crosscut near an air shaft is shown in fig. 8. At this mine all narrow hand work is driven 8 feet wide, and all machine narrow work 10 feet wide.

In 10 of the mines examined in the district top coal was left where the immediate roof over the coal was thick black shale. Top coal prevents variations of temperature and humidity from affecting the shale of the roof proper, which spalls badly when exposed to the air. As a rule when no top coal is left this black shale falls with the coal or is drawn. When there is less than four inches of shale between the coal and the limestone the shale is drawn. Where the latter is over 4 inches thick it is propped in some mines, but in others is drawn unless it is over 2 feet thick.

The per capita production of employees of the district is high compared with that of the remainder of the State because surface roustabout work is well systematized, and because so large a percentage of the total production of the dis-

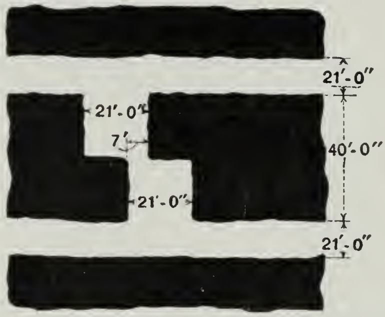

Fig. 6. Offset crosscut.

trict is undercut by machines. In Table 6 are compared for the State, district, and for each mine, items connecting daily production with number of employees.

The accident record of the district is consistent with its production; 34.4 per cent of the fatal accidents in the State and 35.6 per cent of those non-fatal occurred during the year ended

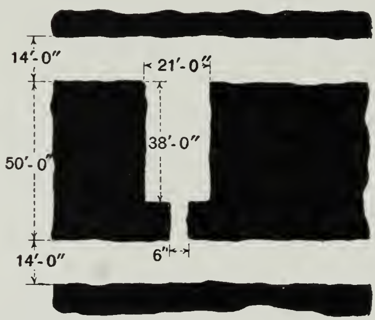

Fig. 7. Method of driving crosscuts.

June 30, 1912; while in the district was produced 39.1 per cent of the coal output of the State. A greater percentage of the fatal and non-fatal accidents in the district is caused by pit cars than in the remaining districts combined; the ratio for fatal accidents from this cause being 24.2 to 16.1 and for non-fatal accidents, 29.5 to 24.4.

TABLE 6.—*Per capita production of employees*

No.	Employees: Surface	Employees: Underground	Employees: Face workers (miners, loaders and machine men)[1]	Employees: Total	Average daily tonnage	Underground employees for each surface employee	Tons per day: Per surface employee	Tons per day: Per underground employee	Tons per day: Per face worker (miners, loaders and machine men)[1]	Tons per day: Per employee	Nationality
66	32	633	422	665	4000	19.8	125.8	6.3	9.5	6.0	American, Italian
67	22	300	242	322	1250	13.6	56.8	4.2	5.2	3.9	Scotch, English
68	29	235	270	364	2500	11.5	86.2	7.1	9.3	6.9	American
69	13	135	79	148	500	10.4	38.5	3.7	6.3	3.5	American
70	27	248	174	275	1650	9.2	66.5	6.7	9.5	6.0	
71	40	400	268	440	2500	10.0	62.5	6.3	9.3	5.7	Italian, Prussian
72	40	602	466	642	4000	15.0	100.0	6.6	8.6	6.2	Italian, American
73	42	518	401	560	3750	12.3	89.3	7.4	9.3	6.7	Italian, Slav
74	30	484	339	514	2800	16.1	93.3	5.8	8.2	5.4	Italian, Hungarian
75	20	330	225	350	2000	16.5	100.0	6.1	8.9	5.7	
76	60	400	268	460	2120	6.6[2]	35.3	5.3	8.0	4.6	Italian, Lithuanian
77	18	275	200	293	2500	15.2	138.9	9.1	12.5	8.5	
78	10	110	182	120	800	11.0	80.0	7.2	9.7	6.6	American
79	17	275	196	292	1700	16.2	100.0	6.2	8.7	5.7	German, Russian
80	12	150	80	162	1000	12.5	83.3	6.6	12.5	6.2	American
81	12	135	108	147	700	11.3	58.5	5.2	....	4.8	German, American
82	35	420	400	455	3000	12.0	85.7	7.1	7.5	6.6	German, Scotch
83	9	130	106	139	650	14.4	72.2	5.0	7.6	4.7	Negro
84	50	350	272	400	2000	7.0	40.0	5.6	7.4	5.0	German, Italian
85	15	250	189	265	1200	16.6	80.0	4.8	6.3	4.5	Lithuanian, Russian
86	17	212	....	229	1800	12.5	105.9	8.5	....	8.2	American
87	25	200	154	225	800	8.0	32.0	4.0	5.2	3.5	American
88	14	190	164	204	1050	13.6	75.0	5.5	6.4	5.1	Italian
89	8	100	96	108	400	12.5	50.0	4.0	4.2	3.7	German
90	10	100	98	110	500	10.0	50.0	5.0	5.1	4.6	American
All other districts combined[3]	4695	46,869	33,973	51,564	218,193	9.9	46.6	4.7	6.4	4.2	
District VII[3]	2354	25,493	19,345	27,847	142,118	10.8	60.5	5.6	7.3	5.1	

[1]Shipping mines only.
[2]Operates a coal-washer.
[3]Compiled from the Thirty-first Annual Coal Report of Illinois.

Table 7 compares causes of accidents for District VII and for the other districts of the State combined.

TABLE 7.—*Causes of accidents to employees.*[1]

Causes of fatal accidents	Percentage	
	District VII	All other districts combined
Fall of rock or coal	54.8	55.1
Pit cars	24.2	16.1
Use of explosives	6.5	7.0
Gas explosions	3.2	8.5
Cause of non-fatal accidents		
Fall of rock or coal	34.7	49.6
Pit cars	29.5	24.4
Use of explosives	3.1	2.3
Gas explosions	1.4	3.7

[1]Compiled from the Thirty-first Annual Coal Report of Illinois.

VENTILATION.

Generally throughout the district ventilation is adequate; in the mines of large production the quantity of air at the face is always ample. The necessity of providing unusually large quantities of air to the working face is eliminated on account of the small amount of gas found in the workings. In 13 of the 25 mines examined no explosive gas was found; only traces of it were found in the other 12. Generally it is present in minute quantities and usually at "slips" or in ancient water channels in the roof. Fig. 9 shows a channel which acts as a drain for gas and water. Gas is found at no other point in the workings. This channel which is just below the roof is about 8 inches deep and 20 feet wide and runs throughout the mine.

Water gages, which were in more general use in this district than in any other in the State at the time field data were collected, were installed in six of the mines examined with an indicated pressure-difference between intake and return varying from ½-inch to 1½ inches. The difference in pressure between the intake and return air-currents can be read directly on the water gage; short-circuiting of the current on account of sudden stopping, leaks, or obstructions in the air course can be detected, and the defect in circulation remedied at once before the supply of air at the working face has been long deficient. Water gages are now required at every mine by a wise provision of the new State mining law.

Thirty readings from a sling psychrometer at working faces in the mines examined gave an average of 93 per cent for summer relative humidity of air at the face, and an average temperature of 66 degrees F. Hygrometer readings taken three times daily throughout the year gave for the return air an average relative humidity of 92 per cent in winter and 97 per cent in summer. The average return air temperature was 62 degrees in winter.

Artificial humidification for the prevention of coal dust explosions is not done in this district. Sprinkling the roads is of little value in increasing the relative humidity of mine

Fig. 8. Shearing the ribs.

air, but does, however, make the work of mules easier by temporarily lessening the amount of dust thrown up by the passage of cars and by the feet of men and animals. Table 8 gives for each mine examined data covering ventilation. The average size of air-shaft for the mines examined is 7 by 12 feet. The air-shaft at each mine is timber lined.

In the mines of smaller production in this district where gob stoppings with unplastered faces are generally used it is seldom possible to obtain actual cost of stopping building because a segregated expense account is seldom kept. For this reason the impression prevails that gob stoppings are the cheapest. At one mine a gob stopping 6 feet thick in a crosscut 21

TABLE 8.—*Ventilation data.*

No.	Depth of air shaft (feet)	Size of air shaft in clear (feet)	No. of compartments	Type of fan[1]	Diameter of fan (feet)	Width of fan (feet)	Material of fan house	Introduction of water	
								Method	Frequency
66	332	8 by 14	2	Miller	18	6	Brick	Exhaust steam in air-shaft	Continuous in winter
								Sprinkling from car	Weekly
67	320	5 by 10	2	Paddle-wheel	20	6	Frame	Sprinkling from car	Weekly
68	387	7 by 12	2	Duncan	22	6	Corrugated-iron	Sprinkling from car	Weekly
69	290	5 by 10	2	Paddle-wheel	16	4	....	Sprinkling from car	Weekly
70	92	8 by 16	2	Paddle-wheel	22	5	Corrugated-iron	Sprinkling from car	Irregular
71	205	8 by 18	2	Sullivan	10	6	Corrugated-iron	Sprinkling from car	Every two weeks
72	287	9 by 12	2	Capel	20	8	....	Exhaust steam in air-shaft	Continuous in winter
								Sprinkling from car	Weekly
73	318	8 by 18	2	Duncan	21	6	....	Pump exhaust in air-course	Continuous
								Sprinkling from car	Irregular
74	330	8½ by 17	2	Paddle-wheel	22	5	....	Sprinkling from car	Weekly
75	310	8½ by 5⅚	2	Crawford	16	2	Brick	Sprinkling from car	Irregular
76	370	11 by 22	3	Capel	15	6	Brick	Sprinkling from car	Weekly
77	462	9 by 16	....	Sullivan	10	5	Brick	Sprinkling from car	Weekly
78	140	7 by 16	2	Paddle-wheel	20	5	Corrugated-iron	Sprinkling from car	Every two weeks
79	127	6 by 8	2	Paddle-wheel	12	4	Frame	Sprinkling from car	Irregular
80	145	7 by 12	2	Capel	20	5	Frame	Sprinkling from car	In winter only
									Irregular
81	200	7 by 14	2	Paddle-wheel	16	4	Corrugated-iron	Sprinkling from car	Monthly
82	192	10 by 7	2	Paddle-wheel	20	5	Corrugated-iron	Sprinkling from car	Irregular
83	140	6 by 16	2	Paddle wheel	14	4	Corrugated-iron	None	
84	320	6 by 8	2	Paddle-wheel	15	8	Brick	None	
85	440	4 by 6	2	Paddle-wheel	22	6	Corrugated-iron	Sprinkling from car	Irregular
86	536	7¼ by 9½	2	Stevens	10	3	Corrugated-iron	Sprinkling from car	Weekly
87	707	6 by 8	1	Paddle-wheel	12	4	Corrugated-iron	Sprinkling from car	Every two weeks
88	85	7½ by 11	2	Capel	20	6	Frame	None	
89	85	6 by 8	2	Paddle-wheel	15	3	Frame	None	
90	160	6 by 12	2	Capel	6	12	Frame	None	

[1] "Paddle-wheel" refers to straight blade type of fan; often homemade.

feet wide and 7 feet high was built at an estimated labor cost of 5.4 cents per square foot of face. Cost of transportation of material could not be estimated. At another mine a gob stopping 12 feet thick was built in a crosscut 7½ feet high and 25 feet wide at an estimated labor cost of 7 cents per square foot of face, not including cost of transportation of material. Fig. 10 shows a well-built gob stopping 20 feet thick in a crosscut 7½ feet high and 13 feet wide. The shale retaining wall is 2 feet thick and 6 feet high. The slack, fireclay and shale that

FIG. 9. Channel in limestone roof.

make up the body of the stopping are tamped as building progresses. After the stopping has been in place one month and the material of which it is built has settled, more fireclay is tamped in along the top.

At one mine stoppings are built of shiplap with shale, slack and fireclay banked on each side of the lumber stopping.

In a few mines of the district concrete is used for stopping material. The system for making concrete blocks is very efficient

Fig. 10. A gob stopping.

at one of the mines. The blocks which are made on the surface, are proportioned as follows: 1 Portland cement; 4 crushed

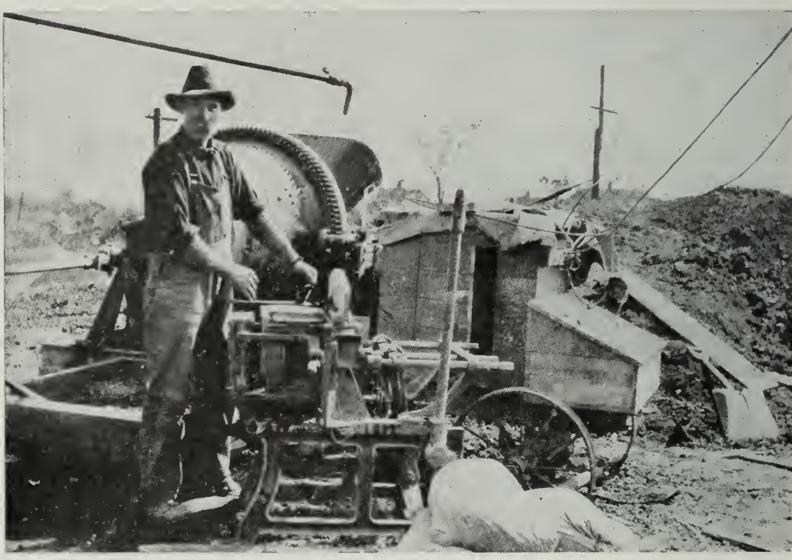

Fig. 11. Mixer and mould for making concrete blocks.

cinders. The mould makes with one filling a block 8 by 8 by 16

Fig. 12. Solid concrete blocks for stoppings.

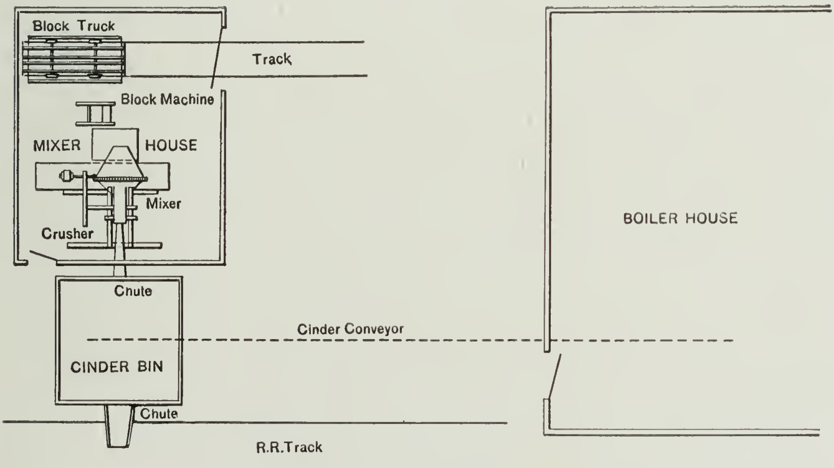

Fig. 13. Arrangement of plant for making concrete blocks. (After Ross).

inches and another 8 by 8 by 8 inches. Two men can make 300 moulds per day, which is equivalent to 450 blocks 8 by 8 by 16 inches, as the 300 smaller block are equal to 150 of the larger. The mixer and mould are illustrated in fig. 11 and fig. 12 shows the blocks as they come from the mould. The arrangement of the plant is shown in fig. 13. A cinder crusher delivers cinders under 1¼-inch mesh and a 6 H. P. Westinghouse motor operates the crusher and the mixer which handles 1/5 of a cubic yard per batch. The cost of manufacturing concrete blocks at this mine is given in Table 9. The costs as given in Table 9

TABLE 9.—*Cost in cents of manufacturing concrete blocks.*

Labor cost per block	Material cost per block	Total cost per block	Square feet of face per block	Cost per square foot of face
1.08	3.88	4.96	0.888	5.58

include delivery at the pit mouth. To obtain a proper set the blocks are ripened on the surface for two weeks. To estimate the cost of a stopping in place, costs of material transportation from the top to the required location in the mine and of stopping construction must be considered. Table 10 gives detailed

TABLE 10.—*Cost of transporting blocks and erecting a ninety-block stopping, 8 by 10 feet.*

Delivery from surface to location in mine	Preparing ribs and building stopping	Cost of material other than blocks	Total cost transportation and erection	Building cost in cents per square foot	Building cost in cents per block
$.71	$2.62 (2 men for 4 hours)	$.70 (2 sacks cement $.60; sand $.10)	$4.03	5.04	4.48

cost of erecting a stopping 8 by 10 feet. Table 11 gives total cost for the stopping in place. As will be seen by Tables 9,

TABLE 11.—*Total cost of completed stopping.*

	Per square foot of surface	Per block
Cost of manufacture in cents	5.58	4.96
Cost of building in cents	5.04	4.48
Total laid cost in cents	10.62	9.44

10, and 11 a tight stopping 8 inches thick is provided at a cost of 10.6 cents per square foot.

Because there is not much gas in the workings the district has had comparative freedom from large fires. Except in the largest producing and most carefully operated mines, precautions against fire which are considered necessary in the mines east of the Duquoin anticline are not taken.

The coal dust of this district is moderately explosive when fine, dry, and unadulterated by shale dust. The average pressure developed by the coal dust of the face-samples when ground to 200-mesh, air-dried, and tested in the explosibility apparatus at Urbana is compared in Table 12 with the pressures developed by the coal dust of other districts.

TABLE 12.—*Pressure developed by dust face samples in explosibility apparatus.*

District	No. Samples	Pressure in pounds per square inch at 2192° F.
I	11	8.400
II	5	5.880
III	5	7.805
IV	17	7.700
V	7	7.105
VI	16	5.950
VII	24	7.175
VIII	6	8.925

In many mines an unnecessary liability of fire is added by allowing comparatively large quantities of lubricating oil to be stored in the run-around or at other points near the shaft. In one mine two full barrels of oil and four empties were kept within 25 feet of the main hoisting shaft, while 200 feet away were stored two full and three empty barrels.

Fifteen of the twenty-five mines had small fires originating from various causes but principally occurring after shots or in the gob. Table 13 gives data in regard to fires for each mine. Gob fires are so frequent in one mine that every fourth room pillar is left solid without crosscuts so that never more than four rooms can be affected by any fire which requires sealing off.

One mine has had three stable fires, two of which were caused by cap lamps. At some mines proper care is not observed in the transportation of hay from the surface to the underground stables. In only a few mines in the district are mules stabled on the surface. The practice of stabling the animals underground increases the fire-risk.

BLASTING.

Undercutting machines are much used in District VII, 60.3 per cent of the coal output during the year ended June 30, 1912, having been undercut. In twenty of the mines examined

TABLE 13.—*Mine firers and methods of sealing-off.*

Mine No.	Has mine had fires?	Fires originated where?	Was sealing off necessary?	Kind of seals
		At face after shots		
66	Yes	In gob	Yes	Shiplap and cement mortar
67	Yes	At face after shots		
		In gob	Yes	Gob
68	Yes	At face after shots	Yes	Gob with concrete facing
69	Yes	In gob	Yes	Brick
70	Yes	In gob	Yes	Gob
71	Yes	At face after shots	No	
72	Yes	At face after shots	No	
73	Yes	At face after shots	No	
74	Yes	In gob	Yes	Gob with concrete facing
75	Yes	In gob	Yes	Gob with concrete facing
76	Yes	In gob	Yes	Cement blocks
77	Yes	At face after shots	No	
		In gob		
78	No			
79	No			
80	Yes	At face after shots	Yes	Shiplap plastered with clay
81	No			
82	No			
83	No			
84	No			
85	Yes	In gob		
		At face after shots	Yes	Double concrete-block wall
86	No			
87	Yes	At face after shots	Yes	Brick
88	No			
89	No			
90	No			

undercutting machines are used, although in some parts of these mines the coal is shot off the solid. Both chain and puncher machines are installed in three mines, chain machines only in ten, and punchers only in seven. The number of tons of coal gained per shift of 8 hours averages 140 per chain machine and 71 for punchers.

The following method of supplying air to puncher machines is typical: From the surface 9-inch mains run down the pipeway in the shaft to a receiver placed 300 feet from the bottom of the shaft. From the receiver a 6-inch line is run to the face of the main entries. This 6-inch line is tapped by a 3-inch branch running to each pair of cross entries; a 1½-inch pipe carries the air from these 3-inch branches to the rooms.

In many mines in the district additional hand-snubbing is done after chain machines and is sometimes extended to a height of 30 inches above the floor at the face. Usually the machine cuttings are loaded out before firing, but in a few mines the dangerous practice of shooting before loading out is permitted.

The positions of drill-holes are different at each mine and their number varies between wide limits. At one mine in rooms 29 feet wide in which puncher undercutting machines have been used, only two holes two feet from the rib and 20 inches from the

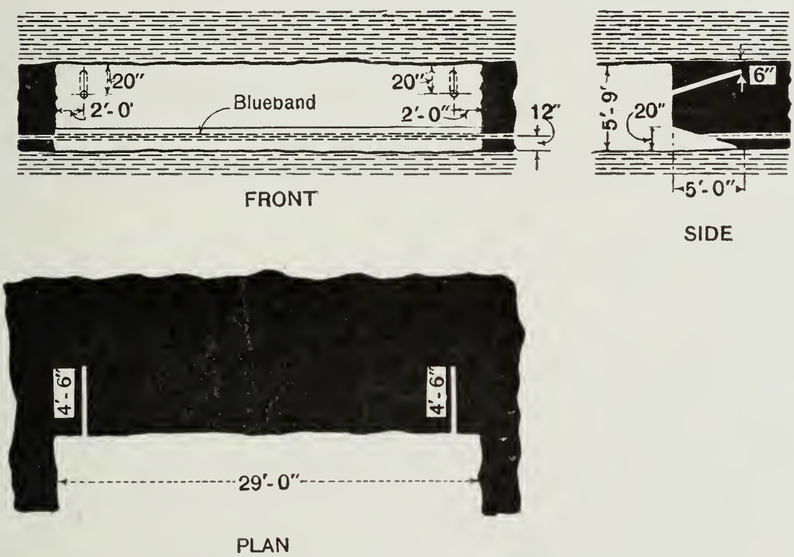

FIG. 14. A method of placing shots after puncher undercutting machine.

roof are drilled, as shown in fig. 14. Figs. 14 to 17, inclusive, show various methods of placing the holes.

In the mines where shooting off the solid is practiced the shooting is done off the weak rib, that is, off the rib presenting the greater area of free surface, as is the custom throughout the State. The difference in amount of powder required for shooting off the solid and for undercut coal is illustrated at one mine where one keg of powder gains 30 tons of coal with solid shooting and 90 tons after puncher undercutting.

Black powder is used exclusively at each of the 25 mines inspected. Black powder is an intimate mixture of sodium nitrate, sulphur, and charcoal. Its explosive effect is caused by the sudden liberation of gases produced by the combustion of the powder grains. The full force of the explosion develops much more slowly than in dynamite, which detonates. In

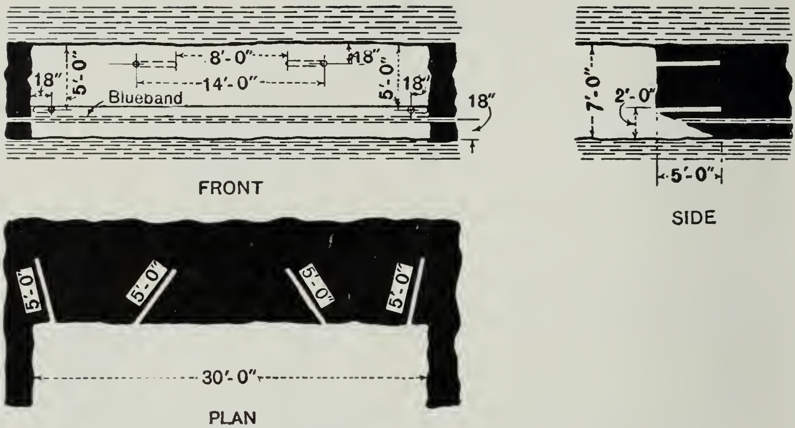

Fig. 15. A method of placing shots after puncher undercutting machine.

black powder the speed of combustion and consequent liberation of gases and development of explosive force is in proportion to the sizes of grains as manufactured. The standard sizes

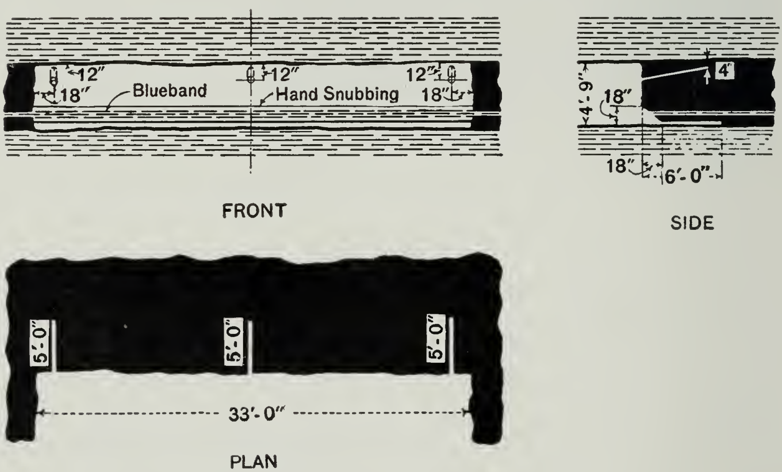

Fig. 16. A method of placing shots after chain undercutting machine.

according to the Revised Mining Statutes of Illinois vary from the largest—which pass through a screen having round perforations $^{40}/_{64}$-inch in diameter—to the smallest, which pass through $^{5}/_{64}$-inch round holes but not through $^{2}/_{64}$-inch ones.

The grades are labeled CCC, CC, C, F, FF, FFF, and FFFF, in order of size; CCC being the largest and FFFF the smallest. The larger the grain, the slower combustion proceeds and the slower does the force of the explosion develop. The sizes in

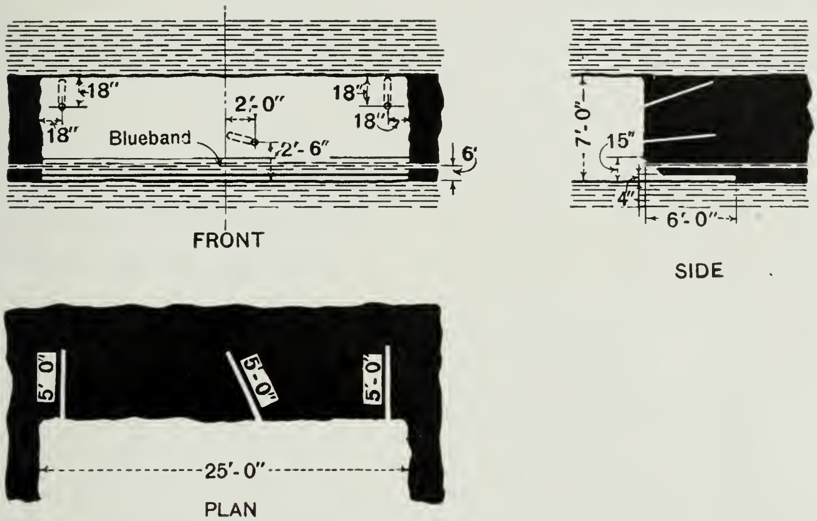

FIG. 17. A method of placing shots after chain undercutting machine.

ordinary use in Illinois range from CC to FF. Size C was used in 10 of the mines examined; CC and C in 1 mine; CC in 2 mines; C and F in 2 mines; F in 8 mines; and FF in only 2 mines. In a comparatively soft material like coal it is obvious that FF, a "quick" powder will have a greater shattering effect than the coarse-grained CC which rends more than it shatters. With a quick powder too much slack coal is made, but since the gross-weight law went into effect FF is the favorite powder with the miners. The waste of coal resulting from its improper use in too large quantities has been very great. This is especially true in undercut coal where the size of the powder is usually too small and the weight of the charge too great. The result of the use of coarse powder in this district is shown by the percentage of lump coal produced. The general use of undercutting machines affects this result, but the percentage of lump is greater in this district than in others where the coal is undercut but a finer powder used.

The transportation of powder from the top to the face according to the general practice throughout the State is done in open pit cars. A more careful handling of powder during

TABLE 14.—*Blasting.*

No.	Kind of undercutting machines	Depth of cut in feet	Tons of coal per machine per shift	Height of snubbing in inches	Size of powder	Pounds of powder per ton of coal	Tons of coal per keg of powder	Powder cost in cents per ton of coal	No. holes per round	Length of holes in feet	Diameter of holes in inches	Shots fired by	Holes per shot-firer	Do windy or blown out shots occur	Percent of coal over 1¼ inches[1]
	Puncher	5½	65							5½					
66	Chain	7	140	30	F	.14	175	1.0	3	7	2	Squibs		Yes	See foot note[2]
67	None	....	......	Solid	C	1.25	20	8.7	4	6	2¾	Fuse	No firers	Yes	65
68	Puncher	5½	80	12	F	.16	157	1.1	4	5	2	Squibs	No firers	Yes	73
69	None	....	......	Solid	C	1.47	17	10.3		7	2	Fuse	20	Yes	60
70	Puncher	5½	65	24	C	.23	111	1.6	4	5	2	Squibs	No firers	Yes	70
71	Chain	5½	150		C	.23	110	1.6	6	5	2	Fuse	No firers	Yes	70
72	Chain	7	127		C	.19	132	1.3		6	1½		No firers	No	75
73	Chain	7	195		C	.13	190	.9	3	6	2¼		No firers	No	72
74	Chain	7	150	15	C	.25	100	1.8	5	6	2¼	Squibs	No firers	No	75
75	None	....	......	Solid	CC	1.04	24	7.3	3	7	3	Fuse	80	Yes	67
76	Chain	6	150	....	C	.28	90	2.0	....	5½	1¾		60	Yes	74
77	Chain	6	125	....	F and C	.25	100	1.8	3	6	2	Squibs	No firers	No	71
78	Puncher	5½	80	18	F	.23	110	1.6	5	5	1½		No firers	No	75
79	Chain	6	120	4	C										
					F	.22	114	1.5	3	6	2	Squibs	No firers	No	71
80	None	....	......	Solid	CC	1.00	25	7.0	5	6	2½	Fuse	58	Yes	
81	None	....	......	Solid	F	.78	32	5.4	....	6½	2½	Fuse	40	Yes	60
82	Puncher	5½	70	18	F	.21	124	1.4	4	5	1½	Fuse	No firers	No	72
83	Puncher	5½	70	20	FF	.31	70	2.5	3	4½	1¾	Squibs	No firers	No	70
84	Puncher	5½	70	20	FF	.22	112	1.5	....	5	1½		No firers	No	72
85	None	....	......	Solid	C and CC	1.00	25	7.0	7	8	2½	Fuse		Yes	86
86	Chain	6	......	4	C	.50	50	3.5	4	8	2	Squibs	50	Yes	
87	Chain	6	100	4	C	.25	100	1.8	3	5	2	Squibs	No firers	Yes	70
88	Puncher	5	70	18		.25	50	1.8							
	Chain	6	130	20	F	.50	100	3.6	2	4½	1½		No firers	No	65
89	Chain	6	......	30	F	.28	89	2.0	3	5	1¼	Fuse	25	No	65
90	Puncher	5	......	20	F	.73	38	5.1	3	4½	2¼	Fuse	20	No	70

[1]For type of screen used see Table 19.
[2]79 percent over ¾-inch.

its distribution to the miners is desirable. This need is emphasized by an occasional explosion during powder distribution with attendant loss of life.

Paper powder kegs were not used in this district and the custom, prevalent in all districts, of driving a pick-point through the head of the steel keg to facilitate pouring out the powder after half or more of it has been used is common. Fatal accidents often result from the miners' practice of loading cartridges while their lamps are on their caps.

Fig. 18. Result of buster and left rib shots.

Only 8 of the 25 mines employed shot-firers. To dispense with them in Illinois mines requires the restriction of the weight of a charge of powder to two pounds. In many cases this restriction is not observed. By relying on large quantities of powder per round the miners are becoming less skillful in placing their shots. In fig. 18 the result of a buster and a left rib shot is shown. The large block of coal in the immediate left fore-ground was blown 27 feet from the face. These shots were fired after undercutting by a puncher machine. Fig. 19 shows the result of an unskillfully placed shot; the pot hole in the face is distinctly shown. The ten-inch block of coal in the foreground was blown 35 feet from the face.

Tough fireclay makes the best tamping material, but as it is easier to use bug-dust, i. e., pick or machine cuttings for filling dummies than to dig clay from the floor, the practice of using bug-dust for tamping is common through the district. It will almost always be used for this purpose wherever the miners are allowed to load and fire their own shots.

Table 14 gives figures on the use of powder and method of shooting at each of the 25 mines. The figures for the tons of coal gained per keg of powder and for the percentage of lump over 1¼ inches were supplied by the operators of the various mines. The size 1¼ inches has been used for each district in order to have a comparison of the percentage made throughout the State.

FIG. 19. Result of unskillfully placed shot.

TIMBERING.

Nearly all mines in the district have large sections of the workings under limestone roof called rock-top, which for reasonable spans requires no support, as shown by the entry in fig. 20. It is seldom, however, that all the workings in a mine are under limestone. Usually some parts have a clod roof with such slight cohesion that it often breaks at the prop; in other parts is a black shale roof also difficult of support and in places drawn when not thicker than four inches. The alternation of a good and bad roof as shown in fig. 21 is productive of many accidents.

In some mines the roof along the entries is supported by props only.

Entry sets are usually made up with timber collars and legs. Steel I-beam collars are rarely used. The three-piece entry set has either vertical legs, as shown in fig. 22 or battered

Fig. 20. Unsupported limestone roof.

legs, as shown in fig. 23. Occasional examples are found of one leg and a crossbar with an end resting in a hitch cut in the

Fig. 21. Alteration of good and bad roof.

rib. A common relation between diameters of timber crossbars and length of span is as follows:

Span in feet	Diameter of crossbar in inches
8	4
10	6
12	8
14	10
16	12
18	14

About one per cent of the average shipment of props is white oak, the remainder consisting of red oak, water oak, elm,

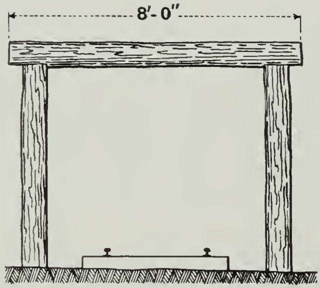

Fig. 22. Three-piece entry set with vertical legs.

hickory and hemlock. It is becoming increasingly difficult in the district to obtain good timber. Because of the frequent failure of that used for crossbars the substitution of steel I-beams as being safer and more economical is suggested. The

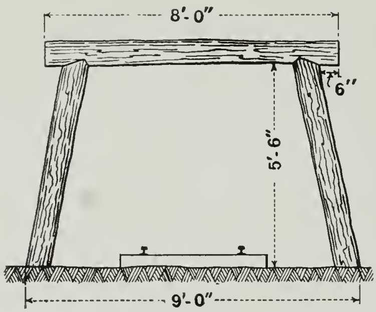

Fig. 23. Three-piece entry set with battered legs.

life of entry timbers varies from six months to five years with an average of eighteen months.

Where roof conditions are so varied unusual examples of timbering may be expected. Fig. 24 shows typical timbering of entries under shale roof. The legs of this three-piece gangway set are 7 feet long and 8 inches in diameter. The crossbars are 8 feet long and 8 inches in diameter. Both legs and crossbars are round red oak, spaced on 2½-foot centers. At one mine there are no crossbars in the entries, as the entire mine has a limestone roof. At another mine which has in places a thick shale deposit overlying the coal, the roof on both sides of the shaft caved to a height of 42 feet from the floor. This cave extended 110 feet along the main entry. Fig. 25 shows the method of timbering the entry in the caved area. The frames shown were set on 4¾-foot centers. Iron rails which are occasionally used as crossbars in entry timbering, should be at least of 70-pound size. Generally throughout the State a rail lighter than 70 pounds has given poor satisfaction as a crossbar and has required early renewal.

FIG. 24. Timbering under shale roof.

None of the mines has a concrete or masonry lined shaft bottom and steel I-beams are used in only a few. Fig. 26 shows the use of steel I-beams and H-bar legs set on concrete foundations. Generally the shaft bottoms are lined with 16 to 24-inch framed timber 3-piece sets carrying 2-inch lagging. Occasionally round, rough timber legs and crossbars 16 to 24 inches in diameter are used.

The roof of rooms in District VII is usually supported by unpeeled split and round props, although in seven of the mines round props exclusively are bought. In eight mines split props alone are used. The average length of room props in the district is 8 feet. The average life is 20 months.

Several typical rooms under shale or clod roof were inspected at each mine. The width of room was measured, and the number of props in place counted in a measured length of room. From these data the number of props per 100 square

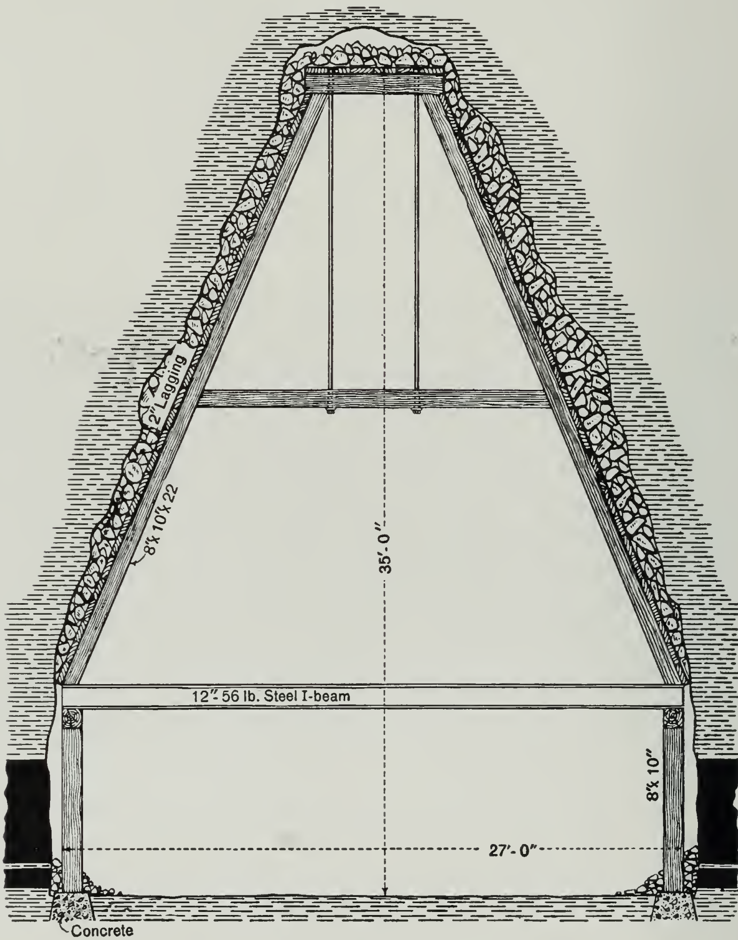

Fig. 25. Timbering in caved area.

feet of roof was calculated. Table 15 gives figures concerning propping in rooms under a roof other than limestone. The costs given in this table apply to unpeeled props, and were supplied in each case by the operating company. Fig. 27 shows typical propping under bad roof.

TABLE 15.—*Props in rooms.*

No.	No. per 100 square feet of roof	Cost in cents per 100 square feet of roof	Diameter in inches	Length in feet	Life in months	Cross bars in rooms?	Round or split	Cost in cents per ton of coal
66	6.0	72.0	4	8	12	No	Both	.....
67	2.7	27.0	4.5	8	12	No	Both	1.0
68	2.7	42.3	4.5	8	36	Yes	Both	2.2
69	2.0	16.0	4.5	8	18	No	Round	0.9
70	6.0	54.0	4.5	7	18	Yes	Both	1.8
71	5.0	50.0	4.5	8	9	Yes	Both	2.8
72	....	......	5	8	18	Yes	Round	1.5
73	....	......	4.5	6	12	Yes	Split	....
74	....	......	4.5	7	12		Round	1.9
75	1.8	25.2	4.5	7	18	Yes	Both	1.6
76	....	......	4.5	7	18	No	Both	2.5
77	4.0	64.0	5.5	8	18	Yes	Both	2.4
78	4.0	42.0	4	7	12	No	Both	1.0
79	2.4	33.6	5	8	24	No	Split	.....
80	....	......	......	......	....	....	......	.....
81	....	......	4	7	24	No	Both	.....
82	7.2a	70.3	4	6½	12	Yes	Split	2.5b
83	5.0	40.0	4	8	24	No	Both	0.6
84	5.0	70.0	4.5	8	12	Yes	Split	.....
85	1.3	11.7	5	7½	24	No	Split	0.5
86	1.9	10.5	4.5	5½	36	No	Both	0.5
87	5.0	32.5	4.5	6½	12	No	Both	3.0
88	5.0	30.0	4	6	Split, 24; round, 48	No	Both	0.5
89	2.8	19.6	4	7	24	No	Split	2.0
90	2.6	18.2	4	7	48	No	Round	.....

a. Including cross bars.
b. Including cost of brushing roof.

The distance from the face at which the nearest prop was found in rooms working under shale or clod roof varied from 7 to 20 feet. With a closer supervision of the miner's place the number of accidents from roof falls at the face could be lessened materially. No miner under shale roof in this district should be allowed to work 20 feet ahead of his last prop. In general throughout the State in small mines good discipline is not maintained in regard to the miner's care of his place. Increasing the number of face bosses would decrease the loss of life, because many miners will not use sufficient care in propping unless forced to do so.

HAULAGE.

The No. 6 bed in this district lies comparatively flat, the grades being steep in only a few mines. Haulage in mines

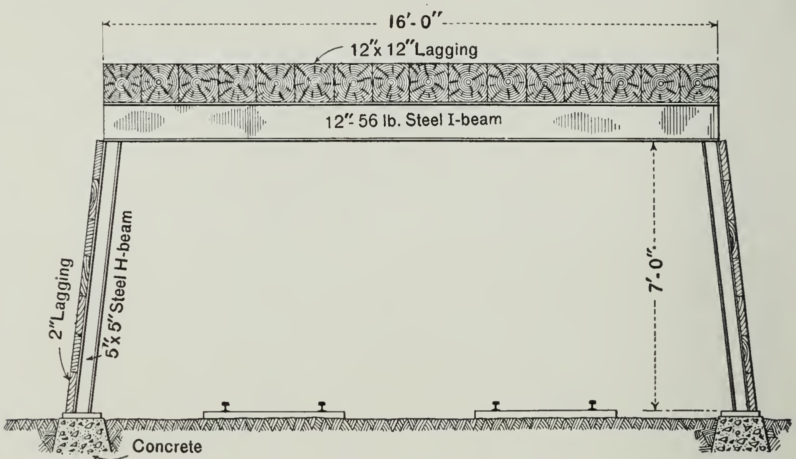

Fig. 26. Steel timbering.

of large production is given the attention deserved, and accordingly a proper expenditure is made on upkeep of track and

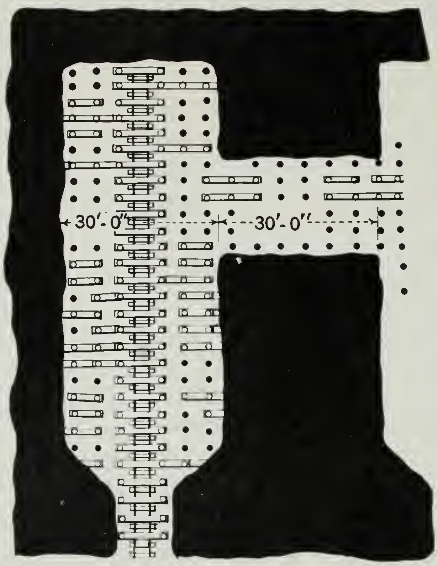

Fig. 27. Typical propping under bad room.

roadbed. The rail weight of the main haulage is not so heavy as it is in new mines east of the Duquoin anticline, but haulage equipment in the district generally is better than the average for the State. Electric locomotives were found in nineteen of the twenty-five mines and gasoline locomotives in two. In only four mines were mules used on the main haulage.

The weight of electric locomotives on the main haulage in the district varies from six to fifteen tons. Where used for gathering, their weight is usually five tons. The six-ton gasoline locomotive is used in two mines where the haul from the partings has become too long for profitable mule haulage. At one mine the gasoline locomotive hauls to the bottom in one shift

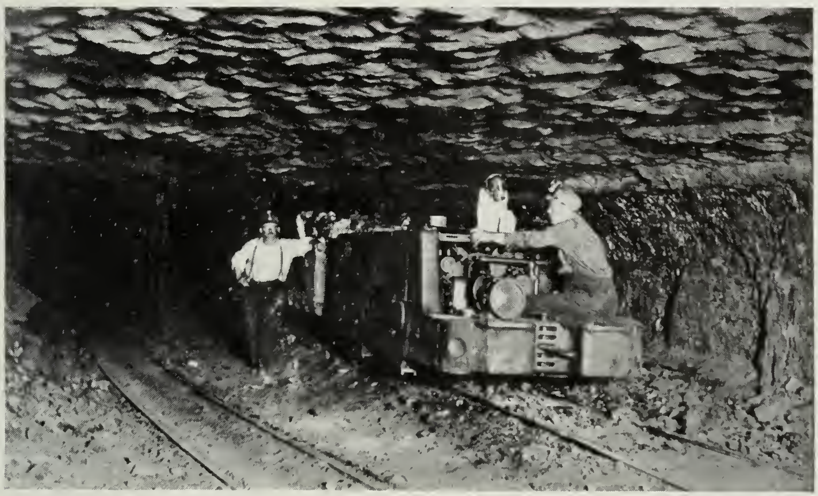

FIG. 28. Six-ton gasoline locomotive.

1300 tons of coal. The gasoline consumed is 18 gallons at a cost of $2.25, making the fuel expense $.0017 per ton of coal hauled. At another mine the gasoline locomotive hauls 900 tons per shift with a gasoline consumption of 15 gallons costing $1.80. This is $.002 per ton of coal hauled. The average trip at this mine is 25 loads of 4000 pounds each including car and coal. Fig. 28 shows a six-ton gasoline locomotive. Gasoline locomotives are subject to the usual defects of the gasoline engine when required to do variable work, and their exhaust of combustion products may limit their use to entries where there is an air-current of large volume and high velocity. Their great advantages are cheapness of installation and flexibility. The necessity of bonding rails, which must be done for electric haulage, is obviated and the change from mule haulage can be made without stringing trolley wires.

The rack-rail electric locomotive was used in two mines. At one the rack-rail was used as a third-rail and the power transmitted through it. At another so much leakage had taken place when the current was sent through the rack-rail that a trolley wire was strung and the locomotive fitted with a pole. The rack-rail locomotive is still used because of the steep grades, which prohibit the use of the standard light-weight electric locomotive. The third-rail in coal mines is not only dangerous but the leakage of power is serious where the floor is damp. Fig 29 shows a three-ton rack-rail electric locomotive. Table 16 gives data on locomotive ton-mileage.

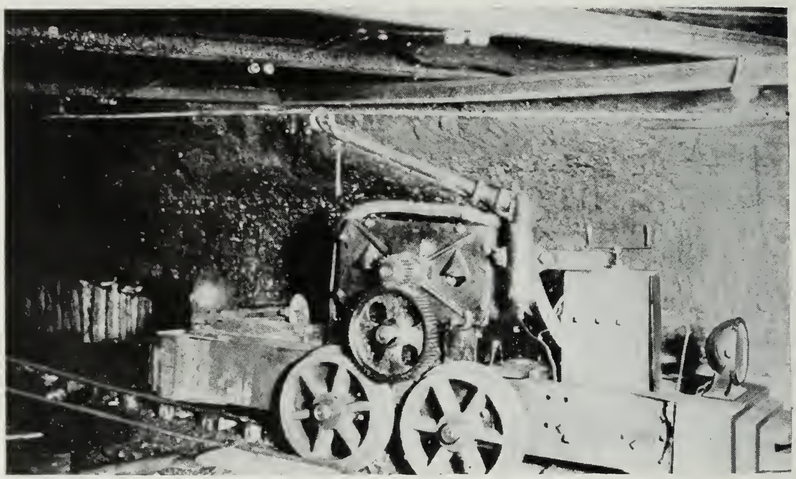

Fig. 29. Three-ton rack-rail locomotive.

The mules in the mines of this district are kept in good condition. Their cost is steadily increasing. Depending on age and condition the price of an 1100-pound mule varies from \$175 to \$275. The increased production of the mines and the substitution of locomotives for mules on the long hauls have limited the work of the animals to gathering. As this must be done at high speed to keep the locomotives supplied with loads the life of a mule has consequently been shortened. In many mines in this district and throughout the State the limit of the average mule's work underground is 3 years. The expense including feed, shoeing and harness repair is estimated to be \$.75 to \$1 a day. It is impossible to obtain average figures on ton-mileage of mules because of no segregation of expense items. In one mine on a 2 per cent grade in favor of the loads two mules weighing 1300 pounds each made seventy-five loaded trips of 700 feet with four cars weighing empty 1000 pounds apiece, each having a capacity of 3500 pounds. With this load and haul the daily ton mileage for each mule was 54.67.

TABLE 16.—*Ton mileage of locomotives.*

Mine No.	Kind of locomotive	Weight of locomotive in tons	Miles traveled per shift	Ton mileage per shift		
				In coal	In cars	Total
66	Electric	15	34.08	1107	716	1823
67	Electric	7.5	47.36	829	769	1598
68	Electric	10	10.61	468	404	875
69	No locomotive	....	....	....	....	....
70	Electric	7.5	41.69	835	502	1337
71	Electric	13	30.28	908	652	1560
72	Electric	12	23.00	667	460	1127
73	Electric	10	....	....	....	....
74	Electric	12.5	26.50	716	716	1432
75	Electric	10	15.14	534	386	920
76	Electric	10	22.72	568	409	977
77	Electric	13	21.03	486	506	992
78	No locomotive	....	....	....	....	....
79	Gasoline	6	12.72	314	154	468
80	No locomotive	....	....	....	....	....
81	Gasoline	5	16.58	311	207	518
82	Electric	12	36.00	2203	1892	4095
83	No locomotive	....	....	....	....	....
84	Electric	12	15.90	444	286	730
85						
86	Electric	12	....	....	....	....
87	Electric	10	32.50	683	683	1366
88	Electric rackrail	5	40.00	823	770	1593
89	Electric rackrail	4	35.00	690	866	1556
90	No locomotive	....	....	....	....	....

Rail weights on the main haulage roads average 30 pounds; on secondary haulage roads 18 pounds. In the 25 mines 40-pound rails, upon which was operated a 15-ton electric locomotive, were the heaviest found. Heavier steel for large locomotives and cars would decrease the number of wrecks and would prove economical because of lessened track repair expense.

The track gages for the district average 36 inches. In nine mines a 42-inch gage was used. On the main haulage in one mine the gage is 48 inches. A track gage of only 24 inches was found in two mines.

In some mines leaky pit cars and frequent wrecks increase the haulage expense. At one mine with a daily production of 1050 tons it is necessary to clean up an average of 20 tons from the haulage way each night because of the many wrecks and the loss of coal from pit cars in transit. At another mine which has low grades, easy curves and a good roadbed the coal lost from pit cars through leaks and by overloading necessitates an average nightly clean up of 24 tons.

Few mines in this district have steel pit cars, or any with roller-bearing wheels, only one of the 25 mines examined having roller-bearing wheels on steel cars. The average weight of

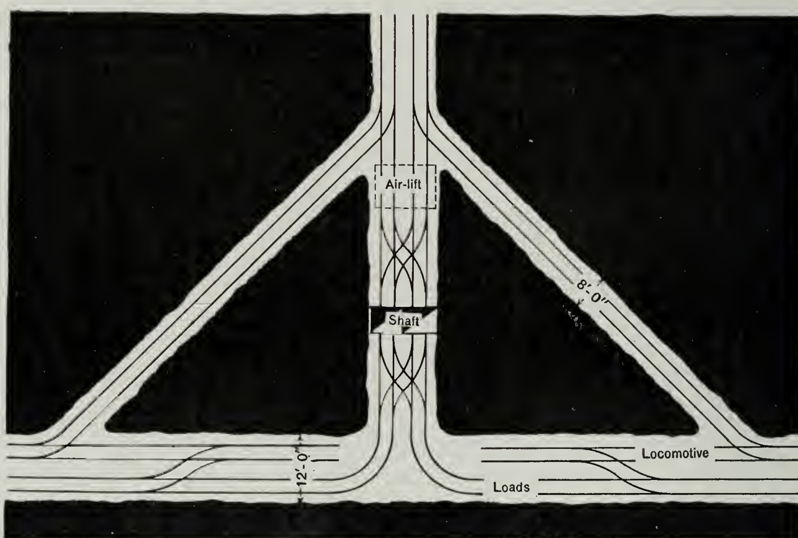

Fig. 30. Air-lift in shaft bottom.

empty pit cars in the 25 mines is 1,884 pounds, and the capacity, 4,734 pounds. Hence, the amount of coal carried in the average car is only 2.51 times the weight of the car. The weight of the average car is 28.4 per cent of the total weight of car and coal. In the 25 mines the average daily production was 1,817 tons, hence 768 average cars were daily taken to the bottom. To get 1,817 tons of coal to the bottom, it was necessary to haul 724 tons of cars, not counting the return trips of empties. The daily excess weight of heavy pit cars hauled unnecessarily in-

TABLE 17.—*Underground haulage.*

No.	Kind of haulage: Main	Kind of haulage: Secondary	Locomotives: Weight in tons and number of each weight[a]	Track gage in inches	Rail weight in pounds per yard: Main haulage	Rail weight in pounds per yard: Secondary haulage	Weight of pit cars in pounds	Capacity of cars in pounds	Ratio of coal to car weight	Percent of car weight in total load
66	Electric	Mules	One 15; one 12; one 6; one 5	42	40	20	2100	6500	3.09	24.4
67	Electric	Mules	Two 13	36	40	18	1300	2800	2.16	31.7
68	Electric	Mules	Two 10	42	30	16	2710	6300	2.32	30.1
69	Mules	Mules	....	24	16	Wood	1100	2800	2.52	28.2
70	Electric	Mules	One 7; one 5	24	30	16	1200	4000	3.33	23.1
71	Electric	Mules	Two 13	42	40	20	2150	6000	2.98	26.4
72	Electric	Mules	Three 12	42	35	20	2000	5800	2.90	25.6
73	Electric	Mules	Two 10	42	30	20	1900	5600	2.93	25.4
74	Electric	Mules	One 12; one 5	42	35	20	3000	6000	2.00	33.3
75	Electric	Mules	Four 10	42	30	18	1700	4700	2.76	26.6
76	Electric	Mules	Three 10; two 5	38	35	16	1800	5000	2.78	26.5
77	Electric	Electric	One 13; ten 5	48	40	20	4000	7700	1.92	34.2
78	Mules	Mules	....	30	30	16	1000	3500	3.50	22.2
79	Gasoline	Mules	One 6	42	30	20	1050	4300	4.18	19.6
80	Electric	Mules	One 6	32	25	16	1400	4000	2.86	25.9
81	Gasoline	Mules	One 6	30	20	16	1000	3000	3.00	25.0
82	Electric	Mules	Three 12; two 5	42	40	20	3000	7000	2.33	30.0
83	Mules	Mules	....	36	20	12	1500	4000	2.66	27.3
84	Electric	Mules	Two 12; one 7; three 5	36	30	20	2000	6200	3.10	24.4
85	Electric	Mules	....	26	30	12	1500	4500	3.00	25.0
86	Electric	Electric	One 12; one 10; two 6; seven 5	42	30	20	2000	7000	3.50	22.2
87	Electric	Mules	Two 10; one 8; one 3	26	35	Wood	1400	2800	2.00	33.3
88	Rackrail	Mules	One 3	30	20	12	1100	2350	2.14	31.9
89	Rackrail	Mules	One 4	36	20	Wood	2200	3500	1.59	38.6
90	Mules	Mules	....	36	16	16	2200	3000	1.36	42.3

a. Figures show weight in tons.

creases the cost of haulage. Table 17 gives data on haulage at each of the 25 mines examined.

HOISTING.

The speed of hoisting common to the mines of large production in the district is remarkable. At the No. 2 mine of the Superior Coal Company at Gillespie, where the bottom of the shaft is 346 feet below the dumping shoes in the tipple, 5,133 tons were hoisted in eight hours on March 24, 1914. In Mine No. 1 of the New Staunton Coal Company at Livingston 1,525 hoists in eight hours were made through a shaft 287 feet deep, an average of 3.18 hoists per minute. From July

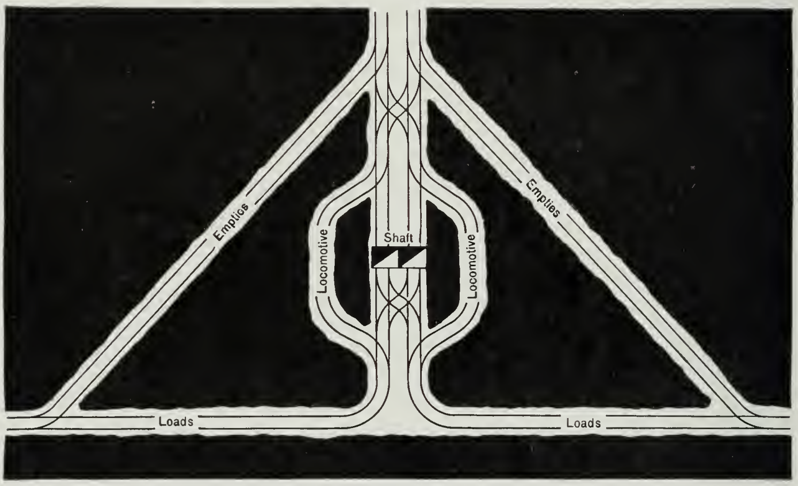

Fig. 31. Typical shaft bottom.

1, 1913 to January 1, 1914, the number of tons hoisted daily at this mine averaged 4,209.

Mechanical devices such as the chain car-haul and the air lift are frequently employed at the large mines for lifting empty cars to main entry level after they have been bumped off the cage by the loaded cars, which are usually caged automatically and approach the shaft on a 2-per cent grade in favor of the loads. Automatic caging is not done in many mines of the district. Fig. 30 shows the plan of a shaft bottom and the location of an air lift. A bottom track arrangement common in the district is shown in fig. 31.

At nearly all mines of moderate production signalling from the bottom to the engine room was done with a modern pneumatic signalling device; but in a few of the small mines the signals for cage movement were transmitted by pulling a wire which rang the engine room bell.

The modern first-motion hoisting engine was found at 23 of the mines; only two had the second-motion engine. In 10 mines the engine size was 24 by 36 inches. Only one mine, with an engine 24 by 42 inches, had a larger cylinder. Conical drums were generally preferred to the cylindrical, and 1¼-inch crucible steel cable was in general use.

Hoisting data for each of the twenty-five mines are given in Table 18.

TABLE 18.—*Hoisting.*

No.	Average daily tonnage	Self-dumping cage	Hoisting shaft		Automatic caging	Hoisting Engine			
								Drum	
			Depth in feet	Size in feet		First motion?	Size in inches	Diameter in feet[1]	Length in feet
66	4000	Yes	332	8 by 14	Yes	Yes	24 by 36	8	3
67	1250	Yes	320	8 by 12	No	Yes	20 by 32	7	4½
68	2500	Yes	387	8 by 15	Yes	Yes	24 by 36	8	3½
69	500	No	290	5½ by 11	No	Yes	16 by 30	6	2¾
70	1250	Yes	92	8 by 13	No	No	12 by 20	5	8
71	2500	Yes	194	8 by 18	No	Yes	20 by 36	6	7
72	4000	Yes	287	8½ by 14½	No	Yes	24 by 36	8	....
73	3750	Yes	318	8 by 17	Yes	Yes	24 by 36	8	8¾
74	2800	Yes	330	9½ by 18	Yes	Yes	24 by 36	8	....
75	2000	Yes	310	8½ by 14	No	Yes	24 by 36	8	6
76	2120	Yes	370	11 by 22	No	Yes	24 by 36	7	6
77	2500	Yes	462	9 by 16	....	Yes	24 by 40	9	5
78	800	Yes	160	7 by 14	No	Yes	18 by 36	6½	4½
79	1700	Yes	127	7 by 15	No	Yes	20 by 36	7	6
80	1000	Yes	145	7 by 14	No	Yes	18 by 36	5	8
81	800	Yes	200	7 by 14	No	Yes	24 by 36	6	6
82	3000	Yes	192	9 by 18	No	Yes	24 by 36	7	8
83	800	Yes	140	8½ by 16	....	Yes	20 by 36	6	3
84	2000	Yes	320	8 by 16	No	Yes	24 by 36	7	5
85	1200	Yes	440	7½ by 16	....	Yes	22 by 36	7	3½
86	1800	Yes	536	9½ by 14½	No	Yes	24 by 42	8	4
87	800	No	707	6 by 14	....	Yes	18 by 32	3	7½
88	1050	Yes	85	7¼ by 11	No	Yes	16 by 32	6	6
89	400	Yes	85	8 by 12	No	Yes	16 by 24	4	8
90	500	No	160	7 by 14	No	No	12 by 24	5½	8

[1]Largest diameter when conical.

PREPARATION OF COAL

The sizes of coal usually made in this district are:

Name.	Size in inches
Six-inch-lump	Over 6
Egg	Through 6; over 3
Two-inch-lump	Through 3; over 2
Screenings	Through 2

At the average mine 25 per cent of the total output is over six inches in size, and 65 per cent is larger than two inches. At three mines the coal under two inches was rescreened in revolving screens varying in length from 16 to 22 feet; in diameter from 2½ to 5 feet; in inclination from 1¾ to 2¼ inches per foot. These screens made about 15 revolutions a minute. The usual sizes made in the rescreeners are:

Name	Size in inches
No. 2 Nut	Through 2; over 1¼
No. 1 Nut	Through 1¼; over ⅝
Pea	Through ⅝; over ¼
Slack	Through ¼

FIG. 32. Inflammable material piled against frame tipple.

The output from a few mines was washed at the mine. In some instances, however, the entire production was shipped to central washeries operated in each case for a group of mines under the same ownership. A description of the washeries in this district is contained in Bulletin 69, Coal Washing in Illinois, by F. C. Lincoln, published by the Engineering Experiment Station of the University of Illinois. The subject of coal preparation will be discussed in a later special bulletin. This report gives only a few general items under this head.

Only one of the twenty-five mines shipped run-of-mine coal exclusively, although at another mine run-of-mine shipments constitute 15 per cent of the yearly product. The percentage of output shipped as mine-run from the other mines examined is so low as to be negligible.

FIG. 33. Frame tipple.

TABLE 19.—*Preparation of coal for market.*

No.	Material of tipple	Primary sizing screen: Type	Length in feet	Width in feet	Inclination, inches per ft.	Shakes per minute	Is coal rescreened or washed?	Percent of total output: Over 1¼ inches	Over 6 inches
66	Steel	Gravity bar	12	6	4	90	Washed	....	....
67	Corrugated iron	Shaker	40	8	3	80	Neither	65	20
68	Corrugated iron	Shaker	28	8	4	66	Washed	73	25
69	Frame	Shaker	18	6	3	80	Neither	60	....
70	Corrugated iron	Shaker	30	7	4	60	Washed	70	40
71	Frame	Shaker	....	7	3	80	Neither	70	32
72	Frame	Shaker	55	8	4	85	Neither	75	33
73	Steel	Shaker	50	7	4	80	Neither	72	40
74	Steel	Shaker	48	7	3	80	Rescreened	75	35
75	Frame	Shaker	36	8	3	80	Neither	67	19
76	Steel	Shaker	50	7	4	100	Washed	74	....
77	Corrugated iron	Shaker	25	10	3	48	Neither	71	32
78	Corrugated iron	Shaker	40	8	3½	90	Neither	75	....
79	Frame	Shaker	30	8	3	95	Neither	71	41
80	Frame	Shaker	30	6	4	90	Rescreened	....	....
81	Frame	Shaker	30	6	4	90	Neither	60	....
82	Steel	Shaker	40	9	4	82	Neither	72	35
83	Corrugated iron	Shaker	32	10	4	90	Neither	70	35
84	Steel	Shaker	30	9	4	90	Washed	72	36
85	Steel	Shaker	25	8	3	....	Neither	....	....
86	Steel	Shaker	....	8	4	92	Neither	67	22
87	Frame	Gravity bar	8	6	4	....	Rescreened	70	38
88	Frame	Shaker	18	6	4	60	Neither	65	....
89	Frame	Shaker	40	6	4	60	Neither	65	15
90	Frame	Gravity bar	30	8	4	....	Neither	70	....

a.Including crossbars.
b.Including cost of brushing roof.

Figures on equipment for preparing coal for market are given in Table 19.

The power plant at each of the mines is equipped with fire-tube boilers. An occasional plant is found where expensive equipment—because of faulty design and arrangement—gives low efficiency. The lack of proper precautions against fire is observable on the surface at many mines as well as underground. Storage of inflammable material near the tipple may be seen at some plants. Fig. 32 shows a frame tipple against which

Fig. 34. Fire-proofed surface plant.

are heaped empty oil barrels and other combustibles. The timber of which some frame tipples are constructed, however, constitute their only fire risk. See fig. 33. A typical fireproof surface plant in the district is shown in fig. 34. Power plant equipment for each mine is given in Table 20.

TABLE 20.—*Surface plant equipment.*

No.	No. loading tracks beneath tipple	No. cars stored above tipple	Boilers			Electric generators		Air compressors	
			No.	Total H. P.	Average steam pressure (pounds per square inch)	K. W.	Volts	No.	Pressure in pounds per square inch
66	3	55	8	1200	110	200	260	2	70
67	3	50	8	900	80	100	250	....	....
68	3	70	10	1250	100	175	250	2	80
69	2	40	3	240	90	......	......	....	....
70	2	30	5	500	90	150	250	2	90
71	4	75	6	1400	110	275	250	1	80
72	5	....	8	1000	120	200	275	....	....
73	4	....	5	750	100	150	250	....	....
74	3	90	6	900	120	175	250	....	....
75	3	50	6	840	100	250	250	....	....
76	6	90	10	1200	120	200	250	1	100
77	4	80	3	750	125	300	250	....	....
78	4	35	4	300	100	......	......	1	85
79	4	32	4	400	110	125	250	....	....
80	2	30	4	500	90	100	250	....	....
81	3	13	1	150	115	......	......	....	....
82	5	100	9	1350	125	250	260	2	90
83	3	50	4	600	110	......	......	1	90
84	4	80	8	1200	110	550	260	2	100
85	3	40	4	450	100	100	250	....	....
86	3	40	5	575	100	200	275	....	....
87	2	40	4	550	100	100	250	....	....
88	1	25	5	400	110	200	250	1	80
89	3	25	3	450	100	75	250	....	...
90	2	8	4	600	80	......	......	1	80